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MODIFICATION AND TEST OF THE CSU-13 B/P G-SUIT FOR USE IN THE F/A-22

Ulf Balldin

WYLE LABORATORIES
1313 SE MILITARY DRIVE, STE 110
SAN ANTONIO, TX 78214

Robert O'Connor
Wayne Isdahl
Paul Werchan

HUMAN EFFECTIVENESS DIRECTORATE
BIOSCIENCES AND PROTECTION DIVISION
AIRCREW PROTECTION BRANCH
2485 GILLINGHAM DRIVE
BROOKS CITY-BASE TX 78235

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F. WESLEY BAUMGARDNER, Ph.D.
Deputy, Biosciences and Protection Division

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Ulf I. Balldin, M.D., Ph.D.; Robert O'Connor, Major; Wayne Isdahl, M. Sc.; Paul Werchan, Ph.D.

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14. ABSTRACT
In order to use the CSU 13 B/P G-suit in the F/A-22, modification of the suit or its aircraft mounted hoses are required. Necessary modifications were produced by the AFRL/HEP division. In unmanned tests the modified CSU-13 B/P G-suit passed all the tests regarding leakage, endurance, proof., burst leakage, and fill rate up to +9 G. Six human subjects were tested in the centrifuge with the CSU 13 B/P G-suit with hose inlet on the right or left side, and with COMBAT EDGE and Advanced Technology G Suit (CE-ATAGS). The tests did reveal any differences in the subjects tolerated G-levels during gradual onset runs with the two 13 B/P G-suits, but CE-ATAGS revealed a statistically significant lowered discomfort level and heart rate. During rapid onset runs G-duration was longer and heart rate was lower with CE-ATAGS. During simulated combat maneuver G-exposures the subjective effort level was lower with CE-ATAGS. Other comparisons did not show any statistically significant differences. In conclusion, no significant differences were shown between the use of CSU 13 B/P G-suit with the hose inlet on left or right side. However, CE-ATAGS showed some benefit over the CSU-13 B/P equipment conditions.

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1.0 SUMMARY: Modification and test of the CSU-13 B/P G-suit for use in the F/A-22

Purpose: In order to use the CSU 13 B/P G-suit in the F/A-22, modifications of the suit or its aircraft mounted hoses are required. In preparation for flight trials such modifications had to be tested in unmanned laboratory tests and in centrifuge tests with human subjects. Comparisons were also made of the two CSU 13 B/P G-suits to the COMBAT EDGE with Advanced Technology Anti-G suit (CE-ATAGS)

Methods: Necessary modifications were produced by the AFRL/HEP fabrication facility. Unmanned laboratory tests of leakage, endurance, proof and burst pressure, structural integrity, and fill rate were done in the laboratory. Six human subjects were tested in the centrifuge with 1) the 13 B/P suit with hose inlet on the right side, 2) hose on the left side connected to an extension hose and 3) CE-ATAGS during different Gradual (GOR) and Rapid (ROR) Onset Run G-exposures and during Simulated Aerial Combat Maneuver (SACM) G-exposures. Different physiological variables were registered and the subjects provided response to subjective effort and comfort levels.

Results/Discussion: In the unmanned tests the modified CSU-13 B/P G-suit passed all of the tests regarding initial leakage, endurance, leakage following endurance test, proof, leakage following proof test, burst leakage following burst test, fill rate to 3, 5 , 7 and 9 G. The centrifuge tests did not reveal any differences in the subjects G-levels during GOR, but CE-ATAGS revealed a statistically significant lowered discomfort level and lower heart rate. During ROR G-duration was longer and heart rate was lower with CE-ATAGS. During SACM the subjective effort level was lower with CE-ATAGS. Other comparisons were not statistically significant. In conclusion, no significant differences were found between the use of the CSU-13 B/P G-suit with hose inlet on left or right side. However, CE-ATAGS showed some benefit over the two CSU-13 B/P equipment conditions.

2.0 BACKGROUND:

F/A-22 Raptor pilots currently wear the Advanced Technology Anti-G Suit (ATAGS), while pilots of all other fighter aircraft wear the CSU-13B/P G-suit. ACC reviewed the G-protection requirements for the F/A-22 and suggested that the current COMBAT EDGE system, which uses positive pressure breathing and the 13B/P G-suit, could meet those requirements. If ATAGS could be replaced by the 13B/P, the USAF will have a standard G-suit throughout the fleet. That standardization will reduce the cost and logistics burden of maintaining two G-suit designs within the life support inventory. Consequently, the Commander of Air Combat Command (COMACC) requested an evaluation of whether the 13B/P suit can be safely used in the F/A-22.

Use of the 13B/P suit in the Raptor requires modification of the suit or the aircraft mounted hoses that attach to the suit. The inlet hose on the 13B/P is on the left side of the suit. This is because in all fighter aircraft, with the exception of the F/A-22, the G-valve that provides air to the suit is located on the left side of the cockpit. The G-valve in the Raptor is located on the right-hand side of the cockpit. Consequently, in order to use the 13B/P in the F/A-22, either the suit's inlet hose must be moved to the right-hand side, or a hose must be routed across the ejection seat from the G-valve to the normal left-hand side inlet hose of the suit.

The AFRL/HEP fabrication facility produced nine 13B/P G-suits with the inlet hose moved to the right-hand side. Additionally, the F/A-22 office at Edwards AFB provided AFRL/HEP with an example of a hose proposed for routing across the ejection seat to allow use of 13B/P suits with standard left-hand inlet hoses. HEP conducted unmanned laboratory tests and centrifuge trials with both the modified suits and the hose/standard-suit combination to ensure adequate inflation rates and burst strength. Appendix A describes the results of those tests and the steps used to modify the nine G-suits. HQ ACC asked that HEP conduct an evaluation with a small number of subjects to verify the results of the unmanned tests in preparation for any flight trial of the modified suits. This report documents the results of the manned centrifuge runs.

3.0 METHODS:

Equipment and facilities: Experiments were conducted in the AFRL/HEP human centrifuge. The AFRL/HEP Cockpit and Equipment Integration Laboratory was used for subject test preparation.

Six volunteer subjects were recruited, two aircrew and four members of the HEP acceleration subject panel. One of the panel members was female. The subject's ages were 23-33 (mean 30), weight 142-220 lbs. (mean 175) and height 68-76 inches (mean 71).

Subjects' activity, food and fluid intake the day prior to each test was *ad libitum*, except for alcohol, which was not allowed.

Three different conditions were tested on different days:

I. 13 B/P G-suit – inlet hose on the right side (modified suit)
II. 13 B/P G-suit – inlet hose on the left side but connected to the extension hose routed across the seat
III. ATAGS

Test Procedures:

Prior to all centrifuge runs, the subjects had standard sternal and biaxillary EKG electrodes attached. The subjects were then dressed in the COMBAT EDGE (CE) equipment listed below. The G-suit consisted of the modified 13 B/P, standard 13 B/P with hose extension, or ATAGS:

Modified HGU-55/P Helmet
MBU-20/P Oxygen Mask
CSU-17/P Counter-pressure Vest
PCU-15A/P or PCU-16 A/P Parachute Harness with LPU-9/P Life Preserver
CRU-94/P Integrated Terminal Block
Anti-G suit

The subjects then proceeded to the centrifuge (F-15 seat configuration) for a G-tolerance assessment. An F/A-22 Breathing Regulator Anti-G (BRAG) valve provided pressure breathing for G (PBG) and G-suit inflation.

For each of the three test conditions, the anti-G suit was inflated according to the standard aircraft schedule. The PBG started at +4Gz, with a linear increase in pressure of 12 mmHg per G, to a maximum of 60 mmHg at +9Gz.

For all test conditions, the following G-profiles were used to evaluate G-suit performance and user comfort:

(a) Relaxed gradual onset (0.1 G/s) run (GOR) to +9 Gz. When the subject reported 100% loss of peripheral vision and/or 50% loss of central vision as determined by peripheral lights at a 60° angle from centerline and a central light, he/she started executing the muscular and respiratory straining maneuvers. End point criteria with straining were when the subject reports 100% loss of peripheral vision and/or 50% loss of central vision.

(b) After a 5 min rest period, the subject was exposed to a series of relaxed rapid onset (6 G/s) runs (ROR) starting at +4 Gz, and increasing by +1 Gz per run, to a maximum of +9 Gz. Each G-exposure lasted 15 s or until vision end point criteria were reached. The subject had a 2 min rest period between exposures.

(c) After a 2 min rest period, the subject continued the G-exposures at one G-level above the earlier maximal successful level in the relaxed ROR, but with the execution of necessary straining maneuvers. This process (2 minutes rest, followed by a one G increase with straining) continued until a maximum of +9 Gz or vision end point criteria were reached. Each G-exposure lasted a maximum of 15 seconds.

(d) After a 10 min rest period the subject performed a simulated aerial combat maneuver (SACM) G-profile consisting of 10-second periods varying between +5 Gz and +9 Gz. This G-exposure continued for a maximum of 4 peaks at +9 Gz.

(e) The subjects also provided response to subjective effort and comfort levels after each ROR exposure and after the SACM by using designated effort and comfort level scales with units from 0 to maximal 11 (11 being most effort or most discomfort).

The total duration of the rapid onset runs was calculated as the sum of the time a subject completed at each G-level attempted. Thus, the maximum possible time for each condition was 90 seconds (six 15-second runs from +4 to +9 Gz). Comparisons of discomfort, heart rate and effort for the different G-suit conditions were done at common G-levels or durations that could be reached during all three conditions. Excepted from this was the effort level after the SACM, which was taken at the completion of the entire SACM.

Statistical analyses:

For each outcome measure, pairwise comparisons of the three suit conditions were made using Student's paired t-tests. In addition, because of the discreet (i.e., non-normal) nature of some of the outcome measures, Wilcoxon signed rank tests were also performed to confirm the results of the t-tests. Generally, the tests were based on a sample of 6 subjects but, due to missing data, sample size ranged from 4 to 6 subjects.

4.0 RESULTS:

The results of the GOR exposures are shown in Table I. No statistical differences in G-levels were found between the three G-suit conditions during relaxed or straining GOR exposures. Table II shows the discomfort ratings and heart rates during GOR with the different conditions I-III. With condition III (COMBAT EDGE and ATAGS), the discomfort level was significantly lower than with condition I (MOD)($p=0.033$), and heart rate was lower than with I (MOD) and II (STD) ($p=.044$ and .002, respectively).

The results of the duration at G, discomfort rating and heart rate of the relaxed ROR exposures are shown in Table III. No statistical differences were found in discomfort rating between the different G-suit conditions, but duration at G was longer under

condition III than under conditions I and II (p=.004 and .030), and heart rate was lower under condition III than under condition I (p=.017).

Table IV shows the duration at G and discomfort rating for the straining rapid onset rate (ROR) G-exposures with the three different G-suit configurations. The truncated durations (90 s was the max attainable value) were not statistically different among the three conditions.

In Table V the effort rating and heart rate are shown during the straining rapid onset rate (ROR) G-exposures. No significant differences were found among the three conditions for effort or heart rate.

The duration at G and discomfort rating are shown in Table VI during the SACM G-exposure with the three G-suit configurations. No significant suit differences were found for duration or discomfort.

Table VII shows the effects of the SACM G-exposure on heart rate and effort rating. No statistical differences were found for heart rate, but for effort, condition III yielded lower scores than did conditions I and II (p=.020 and .052, respectively).

The results of a questionnaire about donning/doffing, connecting/disconnecting and performance under high G (>7G) of the three G-suit conditions are shown in Table VIII. The results of a questionnaire about the compatibility with other equipment, the overall fit of the G-suits, and overall comfort of the G-suits are shown in Table IX, and results of a questionnaire about overall performance of the G-suits are shown in Table X.

Subjects' ratings of the G-suit conditions regarding overall G-protection, fatigue and overall comfort are shown in Table XI.

5.0 DISCUSSION:

There were no significant differences in G-tolerance, heart rate, effort and discomfort between conditions I and II (hose inlet on right or left side), as could be anticipated. There should not be any major differences in the function of the G-suit by having the hose inlet on the left or right side.

From the questionnaire, no subjective major differences were found in donning/doffing, connecting/disconnecting, performance under high G (>7G), compatibility with other equipment, overall fit of the G-suit, and overall performance of the G-suit between having the hose inlet on the left or right side.

The ratings of overall protection, fatigue and overall performance were about the same for conditions I and II, which also could be anticipated.

The only statistical differences found were that COMBAT EDGE, in combination with ATAGS, showed a lower discomfort level and lower heart rate during GOR, and longer

duration at G and lower heart rate during relaxed ROR than for the two other equipment conditions (I and II). During the SACM the COMBAT EDGE/ATAGS combination also showed a lower effort level than the other two equipment conditions, indicating that this equipment may contribute to a somewhat better G-protection. This was anticipated from other studies (2, 3).

Subjects also tended to rate the COMBAT EDGE/ATAGS combination better than the other two equipment conditions with regard to overall G-protection and fatigue level after G-exposure.

In conclusion, no significant differences were found between use of the CSU-13B/P G-suit with the hose inlet on the left or right side in the investigated aspects. However, the combination of COMBAT EDGE and ATAGS showed some benefits over the two CSU-13B/P equipment conditions.

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7.0 TABLES:

Table I. The relaxed and straining gradual onset rate (GOR) G-exposures with the three different anti-G suit configurations (I-III): G-levels attained.

Subject	**GORrel G Mod. I**	**GORrel G Std II**	**GORrel G ATAGS III**	**GORstr G Mod. I**	**GORstr G Std II**	**GORstr G ATAGS III**
1*	6.5	5.6	5.2	9	9	9
2*	6.4	4.8	5.6	8.1	7	8.2
3	7.8	7.5	8.1	9	9	9
4	5.8	5.4	5.9	9	9	9
5	8.6	9	9	9	9	9
6	9	9	9	9	9	9
Mean	7.4	6.9	7.1	8.9	8.7	8.9
SD	1.3	1.9	1.8	0.4	0.8	0.3

* pilot

Table II. The relaxed and straining gradual onset rate (GOR) G-exposures with the three different anti-G suit configurations (I-III): discomfort rating with use of the 1-11 unit scale and heart rate (HR, beats per minute).

Subject	**GORstr Discomf Mod. I**	**GORstr Discomf Std II**	**GORstr Discomf ATAGS III**	**GORstr HR Mod. I**	**GORstr HR Std II**	**GORstr HR ATAGS III**
1. *	9	10	7	145	155	145
2. *	9	5	7	147	150	145
3.	1	1	1	130	130	120
4.	7	5	5	150	140	125
5.	10	11	5	140	130	125
6.	3	2	2	145	150	137
Mean	6.5	5.7	4.5	143	143	133
SD	3.7	4.1	2.5	7	11	11

* pilot

Table III. The relaxed rapid onset rate (ROR) G-exposures with the three different anti-G suit configurations (I-III): duration at G in seconds, discomfort rating with use of the 1-11 unit scale and heart rate (HR, beats per minute).

Subject	**RORrel Duration Mod. I**	**RORrel Duration Std II**	**RORrel Duration ATAGS III**	**RORrel Discomf Mod. I**	**RORrel Discomf Std II**	**RORrel Discomf ATAGS III**	**RORrel HR Mod. I**	**RORrel HR Std II**	**RORrel HR ATAGS I**
1. *	36	21	49	3	3	2	105	105	105
2. *	51	37	65	9	3	6	150	130	130
3.	37	53	53	0	0	1	100	100	85
4.	51	51	66	2	2	1	110	112	100
5.	74	75	90	4	7	2	140	112	105
6.	90	1)	90	3	1)	3	150	1)	130
Mean	57	47	69	3.5	3.0	2.5	126	112	109
SD	21	20	18	3.0	2.5	1.9	23	11	18

* pilot 1) missing value

Table IV. The straining rapid onset rate (ROR) G-exposures with the three different anti-G suit configurations (I-III): duration at G in seconds and discomfort rating with use of the 1-11 unit scale).

Subject	**RORstr Duration Mod. I**	**RORstr Duration Std II**	**RORstr Duration ATAGS III**	**RORstr Discomf Mod. I**	**RORstr Discomf Std II**	**RORstr Discomf ATAGS III**
1. *	90	90	90	10	10	7
2. *	64	65	90	10	6	7
3.	90	90	90	3	0	2
4.	67	75	90	2	3	2
5.	90	90	90	4	9	2
6.	83#	1)	90	#	1)	2
Mean	81	82	90	5.8	5.6	3.7
SD	12	12	0	3.9	4.2	2.6

* pilot 1) missing value # G-LOC

Table V. The straining rapid onset rate (ROR) G-exposures with the three different anti-G suit configurations (I-III): effort rating with use of the 1-11 unit scale and heart rate (HR, beats per minute).

Subject	RORstr Effort Mod. I	RORstr Effort Std II	RORstr Effort ATAGS III	RORstr HR Mod. I	RORstr HR Std II	RORstr HR ATAGS III
1. *	10	10	7	150	150	130
2.*	8	10	9	150	125	162
3.	3	3	2	145	140	125
4.	4	3	2	150	155	145
5.	11	11	1	150	130	125
6.	#	1)	2	125#	1)	137
Mean	7.2	7.4	4.2	145	140	137
SD	3.6	4.0	3.5	10	13	14

* pilot 1) missing value # G-LOC

Table VI. The simulated aerial combat maneuver (SACM) G-exposures with the three different anti-G suit configurations (I-III): duration at G in seconds and discomfort rating with use of the 1-11 unit scale).

Subject	SACM Duration Mod. I	SACM Duration Std II	SACM Duration ATAGS III	SACM Discomf Mod. I	SACM Discomf Std II	SACM Discomf ATAGS III
1. *	62	40	88	10	10	7
2. *	16	18	60	5	10	10
3.	88	88	88	3	2	3
4.	88	88	88	6	4	4
5.	66	66	88	11	11	4
6.	88	1)	88	4	1)	2
Mean	68	60	83	6.5	7.4	5.0
SD	28	31	11	3.3	4.1	3.0

* pilot 1) missing value

Table VII. The simulated aerial combat maneuver (SACM) G-exposures with the three different anti-G suit configurations (I-III): heart rate (HR, beats per minute) and effort rating with use of the 1-11 unit scale).

Subject	SACM HR Mod. I	SACM HR Std II	SACM HR ATAGS III	SACM Effort Mod. I	SACM Effort Std II	SACM Effort ATAGS III
1. *	155	155	150	11	11	8
2. *	155	160	166	10	10	8
3.	145	155	135	3	3	2
4.	165	170	137	7	5	4
5.	150	140	130	11	11	11
6.	160	1)	143	3	1)	2
Mean	155	156	144	7.5	8.0	5.8
SD	7	11	13	3.8	3.7	3.7

* pilot 1) missing value

Table VIII. The result of the questionnaire about donning/doffing, connecting/ disconnecting and performance under high G (>7G) of the three G-suit conditions.
1 means very unsatisfactory, 2 unsatisfactory etc. to 6 very satisfactory.

Subject	Ease donning/doffing G-suit			Connect/disconnect G-hose			Performance under >7G		
	Mod. I	Std II	ATAGS III	Mod. I	Std II	ATAGS III	Mod. I	Std II	ATAGS III
1. *	1)	5	5	1)	5	6	1)	4	6
2. *	5	6	5	6	6	5	5	5	6
3.	5	5	5	5	5	6	5	5	6
4.	5	5	5	5	5	5	4	4	6
5.	6	6	5	6	6	6	5	5	6
6.	6	1)	5	6	1)	6	5	1)	6
Mean	5.4	5.4	5	5.6	5.5	5.6	4.8	4.8	6
SD	0.5	0.6	0	0.5	0.6	0.5	0.4	0.5	0

* pilot 1) missing value

Table IX. The result of the questionnaire about the compatibility with other equipment, the overall fit of the G-suit, and the overall comfort of the G-suit. 1 means very unsatisfactory, 2 unsatisfactory etc. to 6 very satisfactory.

Subject	Compatibility with other equipm			Overall fit of G-suit			Overall comfort of G-suit		
	Mod. I	Std II	ATAGS III	Mod. I	Std II	ATAGS III	Mod. I	Std II	ATAGS III
1. *	1)	4	6	1)	3	6	1)	3	6
2. *	5	5	*	5	5	6	4	5	6
3.	6	5	6	6	6	6	6	5	5
4.	5	5	5	6	4	5	6	4	6
5.	6	6	6	6	6	6	6	6	6
6.	6	1)	6	5	1)	6	5	1)	6
Mean	5.6	5.3	5.8	5.6	5.3	5.8	5.4	5.0	5.8
SD	0.5	0.5	0.5	0.5	1.0	0.4	0.9	0.8	0.4

* pilot

1) missing Value

Table X. The result of the questionnaire about overall performance of the G-suit. 1 means very unsatisfactory, 2 unsatisfactory etc. to 6 very satisfactory.

Subject	Overall performance of G-suit		
	Mod. I	Std II	ATAGS III
1. *	1)	4	6
2. *	4	5	6
3.	6	6	6
4.	5	5	6
5.	4	5	6
6.	5	1)	6
Mean	4.8	5.3	6.0
SD	0.8	0.5	0.0

* pilot

1) missing value

Table XI. Ratings of which G-suit condition being the best regarding overall G-protection, fatigue and overall comfort. 1 is best and 3 is worst. Sometimes there was a tie (a 2 score) for conditions I and II.

Subject	Overall G-protection			Fatigue			Overall comfort		
	Mod. I	Std II	ATAGS III	Mod. I	Std II	ATAGS III	Mod. I	Std II	ATAGS III
1. *	2	2	1	2	2	1	2	2	1
2. *	2	2	1	2	2	1	2	2	1
3.	2	2	1	2	2	1	1	1	2
4.	2	2	1	2	2	1	1	1	2
5.	3	2	1	3	2	1	3	2	1
6.	1)	1)	1)	1)	1)	1)	1)	1)	1)
Mean	2.2	2.0	1.0	2.2	2.0	1.0	1.8	1.6	1.4
SD	0.4	0.0	0.0	0.4	0.0	0.0	0.8	0.5	0.5

* pilot

1) missing value

8.0 Appendix A: Outline of the Modification Process of the CSU-13B/P Suits

The following is a general outline of the steps involved in modifying the CSU-13B/P G-suits to place the inlet hose on the right-hand side. It is not intended to be used as detailed instructions for the modification process.

1. Remove all stitching on the front abdomen panel holding the liner/bladder intact.

2. Remove stitching at bladder tabs (three tabs on thigh and one tab at ankle).

3. Separate liner/bladder from restraint (liner is on the abdomen/hose section only, leg liner remains on restraint).

4. Remove stitching that holds legs to abdomen.

5. Remove slide fastener (zipper) from waist panel.

6. Remove two snap tabs (save for replacement).

7. Remove bias binding from upper and lower edges of abdomen panel (save for replacement).

8. Remove three reinforcement strips on front of abdomen panel (save for replacement).

9. Remove leather reinforcement from hose opening (save for replacement).

10. Remove webbing from bias reinforcement on right side seam of abdomen panel.

11. Remove bias reinforcement from right side seam of abdomen panel (save for replacement).

12. Remove stitching from right side seam separating front and back abdomen panels (save back panel).

13. Using the front panel as a pattern, cut a new panel from Nomex. Mark new Nomex front panel on the wrong or underside of material for hose opening to be on the right hand side instead of the left. Mark new front panel for replacement of three reinforcement strips.

14. Cut a 3 1/4" square piece of Nomex. On the wrong side or underside of the 3 1/4" square piece of Nomex, use a 1 3/8" circle template to draw a circle centered on the square of Nomex. With right sides together, match the circle drawn on the square to the circle drawn on the front panel. Stitch on circle. Cut inside circle and trim out material to within 1/4" of stitching. Clip to stitching. Turn excess of square material to wrong side or underside of front abdomen panel. Stitch around edge of circle. Fold under outer edges of square 3/8" on all four sides. Stitch outer edge of square, stitching through the

square and the front panel. On underside of front panel, reattach saved leather reinforcement, stitching at edge of circle and around outer edges of octagon.

15. On outside or right side of front panel, attach three reinforcement strips in appropriate places.

16. Stitch front panel to back panel on left side seam. Attach bias reinforcement strip over side seam. Attach webbing loop for hanging.

17. Reattach bias binding to upper and lower edges of abdomen panel.

18. Install new (for left side) waist slide fastener (zipper) and facing. Shorten zippers in stock to fit.

19. With use of a box stitch, attach webbing with snaps on underside of left back panel.

20. Reattach legs to front abdomen panel.

21. Insert bladder/liner into restraint, insert hose through hose opening. Pull leg bladder tabs through openings.

22. Position bladder and liner on abdomen front panel. Stitch abdomen bladder in place with double row of stitching. Stitch leg bladder tabs in place with double row of stitching.

23. Install webbing on zipper pull and bottom of zipper.

The following tests were conducted with the initial modified CSU-13B/P G-suit.

Tests Completed:

Leakage Test: inflate to 11 psig, leakage less than or equal to 0.5 psi for one minute

Endurance Test: 6,000 inflations to operational pressure (11 psig) without structural defects

Proof Pressure Test: inflate to 13.7 psig for 15 seconds, without structural defects

Burst Pressure Test: inflate to 17.5 psig for 15 seconds, without catastrophic failure

Structural Integrity: exposure to +9 Gz for 15 seconds without structural defects

Fill Rate Test: exposure to 3Gz, 5Gz, 7Gz, and 9Gz for 15 seconds each - suit should achieve 90 percent of final pressure within 1 second of reaching peak G-level

Test Results:

Initial leakage test

Starting pressure:	11.23 psig
Pressure after one minute:	11.15 psig
Rating:	Pass

Endurance Test

Completed 6020 inflations of the suit to 11 psig

No evidence of any structural defects after the inflations

Rating: Pass

Leakage Test Following Completion of Endurance Test

Starting pressure:	11.23 psig
Pressure after one minute:	11.02 psig
Rating:	Pass

Proof Test

Suit inflated to 13.7 psig for 15 seconds

No evidence of any structural defects after the test

Rating: Pass

Leakage Test Following Completion of Proof Test

Starting pressure:	11.10 psig
Pressure after one minute:	10.93 psig
Rating:	Pass

Burst Test
Suit inflated to 18.0 psig for 15 seconds
No evidence of any structural defects after the test
Rating: Pass

Leakage Test Following Completion of Burst Test
Starting pressure: 11.25 psig
Pressure after one minute: 11.08 psig
Rating: Pass

Fill Rate Test to 3G
Time to 90% pressure 0.7 secs
Rating: Pass

Fill Rate Test to 5G
Time to 90% pressure 0.5 secs
Rating: Pass

Fill Rate Test to 7G
Time to 90% pressure 0.5 secs
Rating: Pass

Fill Rate Test to 9G
Time to 90% pressure 0.7 secs
Rating: Pass

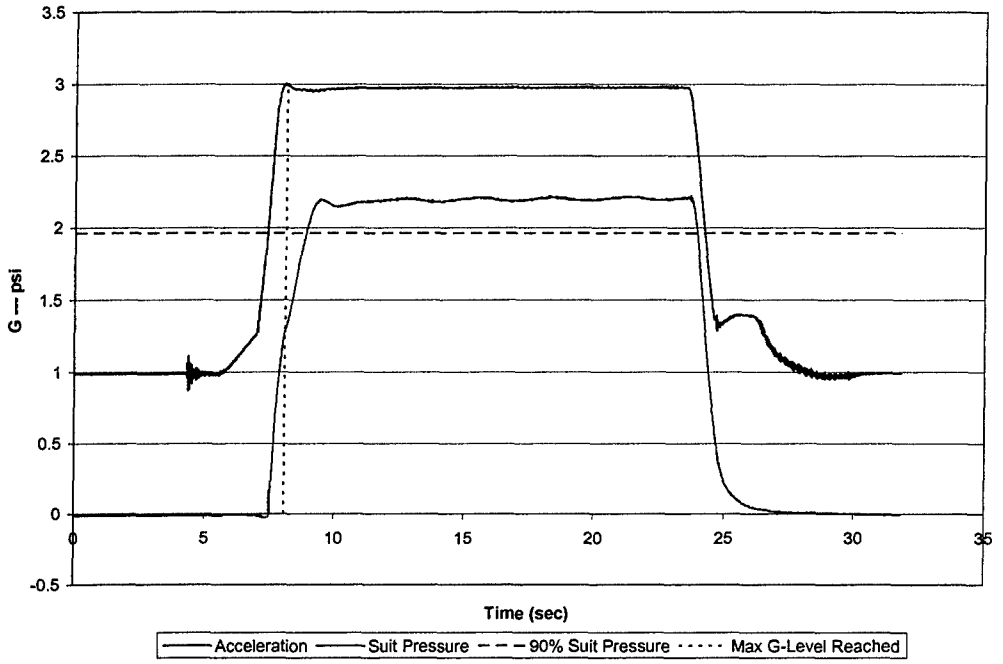
Graphs of Fill Rate Tests Provided Below

Structural Test to 9Gz
No evidence of structural defects after the test
Rating: Pass

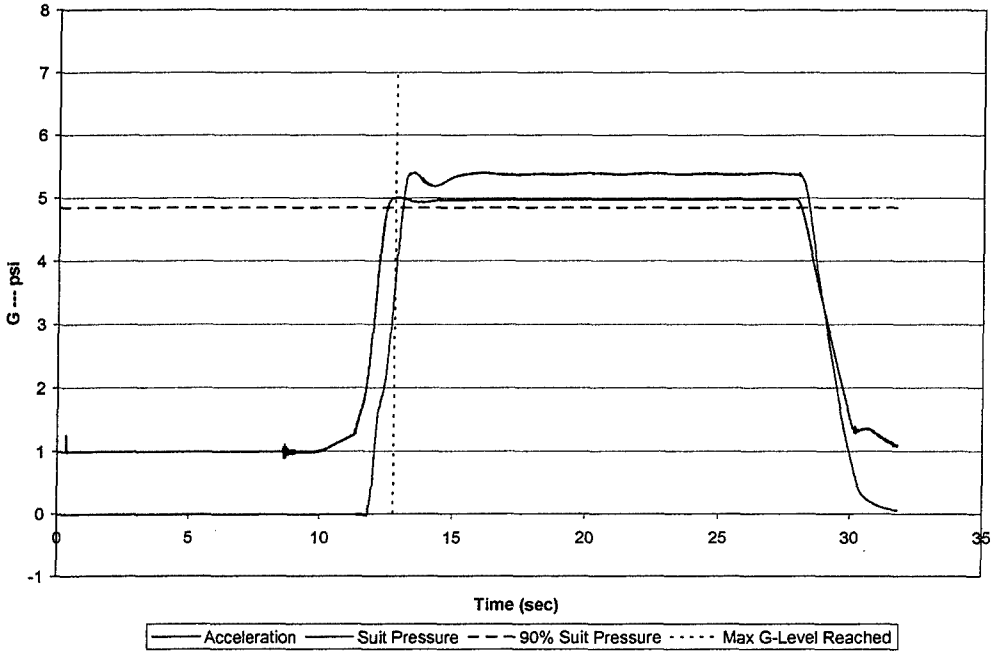
Leakage test results of the 4 suits delivered to Edwards AFB are on page 8

Results of Fill Rate Test

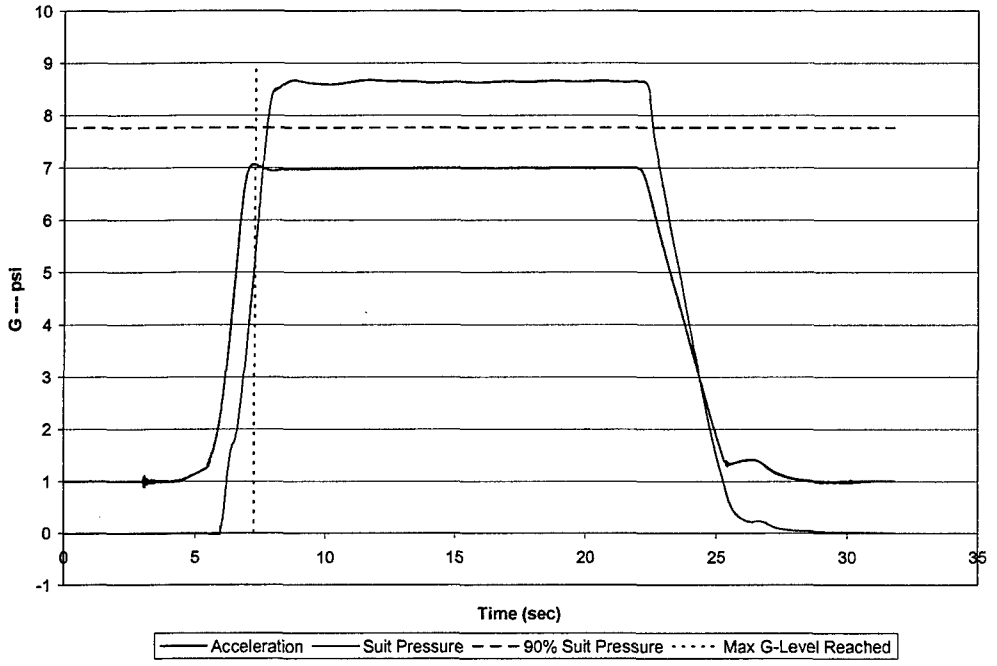
CSU 13B/P with F-22 BRAG Valve
time from max G to 90% pressure .7sec
ROR to 3G



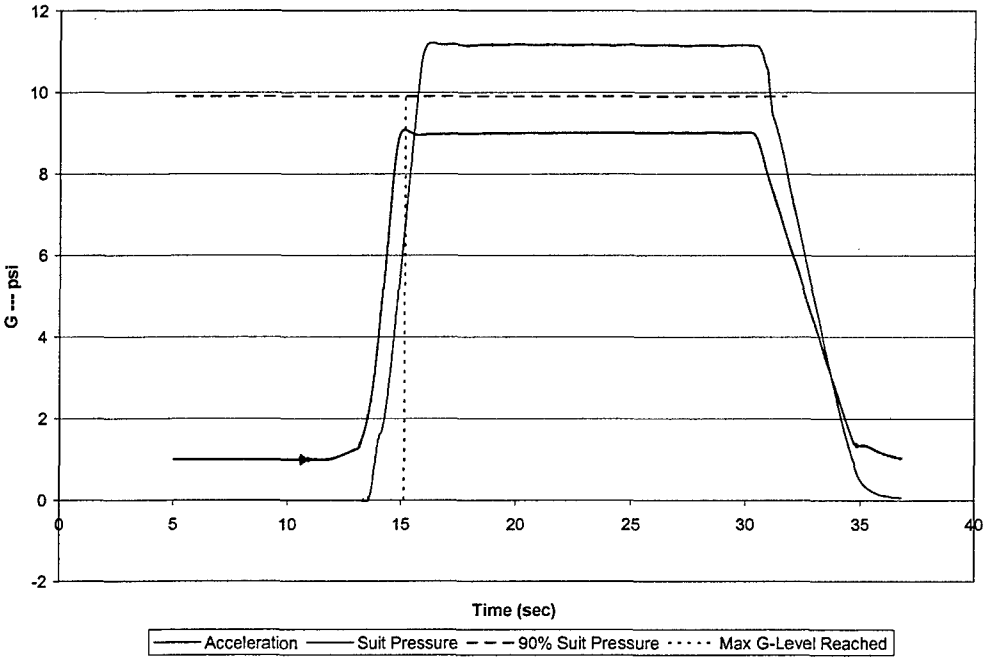
CSU 13B/P with F-22 BRAG Valve
time from max G to 90% pressure .5 sec
ROR to 5G



CSU 13B/P with F-22 BRAG Valve
time from max G to 90% pressure .5 sec
ROR to 7G



CSU 13B/P with F-22 BRAG Valve
time from max G to 90% pressure .7 sec
ROR to 9G



Leakage Tests of Four Suits Delivered to Edwards AFB for cockpit integration tests:

After the suits were modified they were pressure tested at 11 psi for 1 minute. Requirement for passing the test was a leakage of less than 0.5 psi.

	Suit 1 (S/N120897)	**Suit 2 (S/N120097)**	**Suit 3 (S/N102090)**	**Suit 4 (S/N104359)**
Initial PSI	11.53	11.16	11.59	11.53
PSI @ 1 minute	11.25	10.98	11.39	11.25
Leakage	0.28	0.18	0.20	0.28